Solar Occultation Data Validation and Trends Analysis

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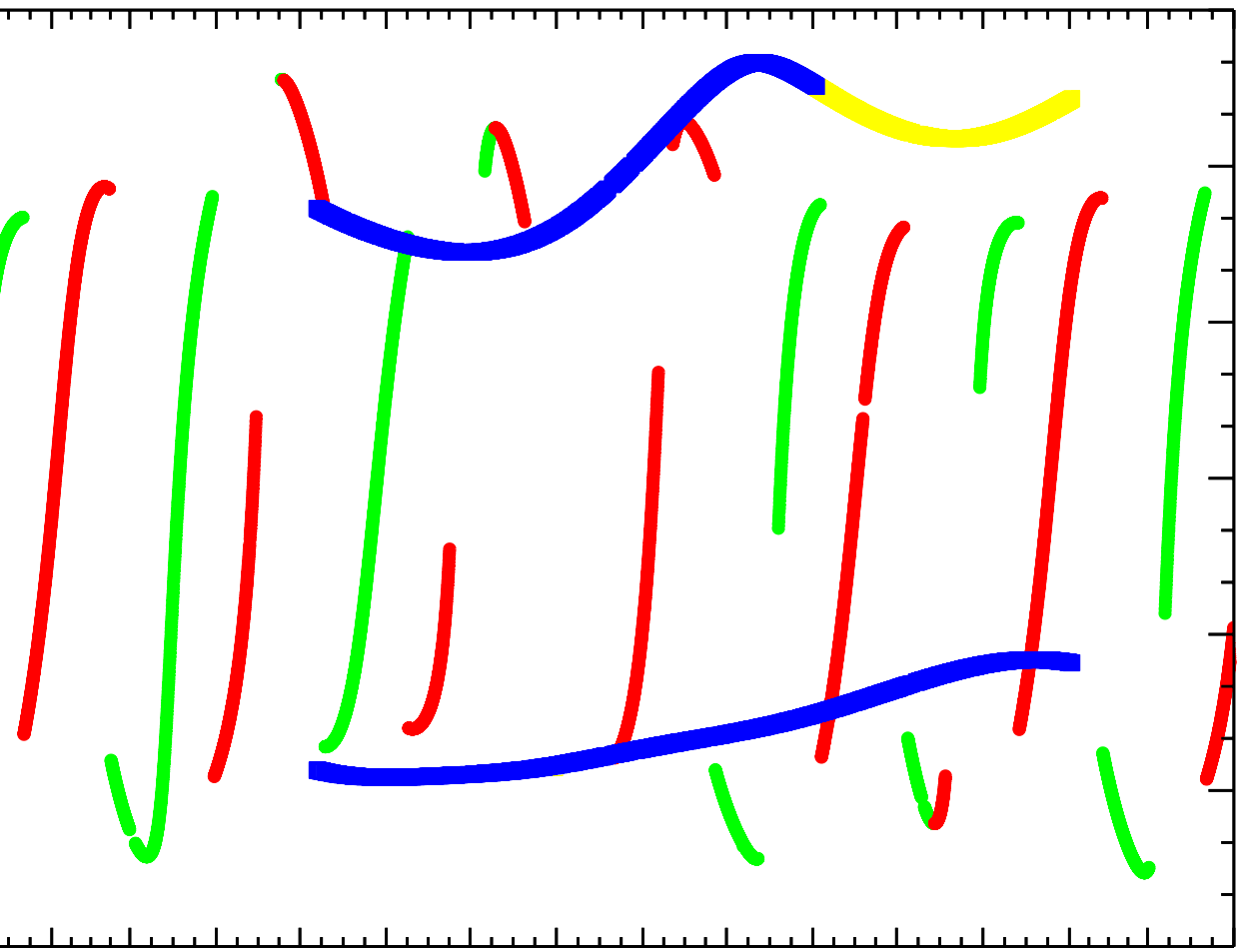
SOSST Research Outline

- SAGE III O_3 Validation
  - Coincident SAGE II O_3 Profiles
  - SAGE II O_3 Climatology (Bridgework)

- SAGE II and HALOE Trends Analysis
  - Difference Time Series

- Validation and Analysis of the Upcoming HALOE v20
  - Upper Troposphere/Lower Stratosphere H_2O and O_3
  - Climatology

SAGE II/SAGE III Coverage for 2002-2003

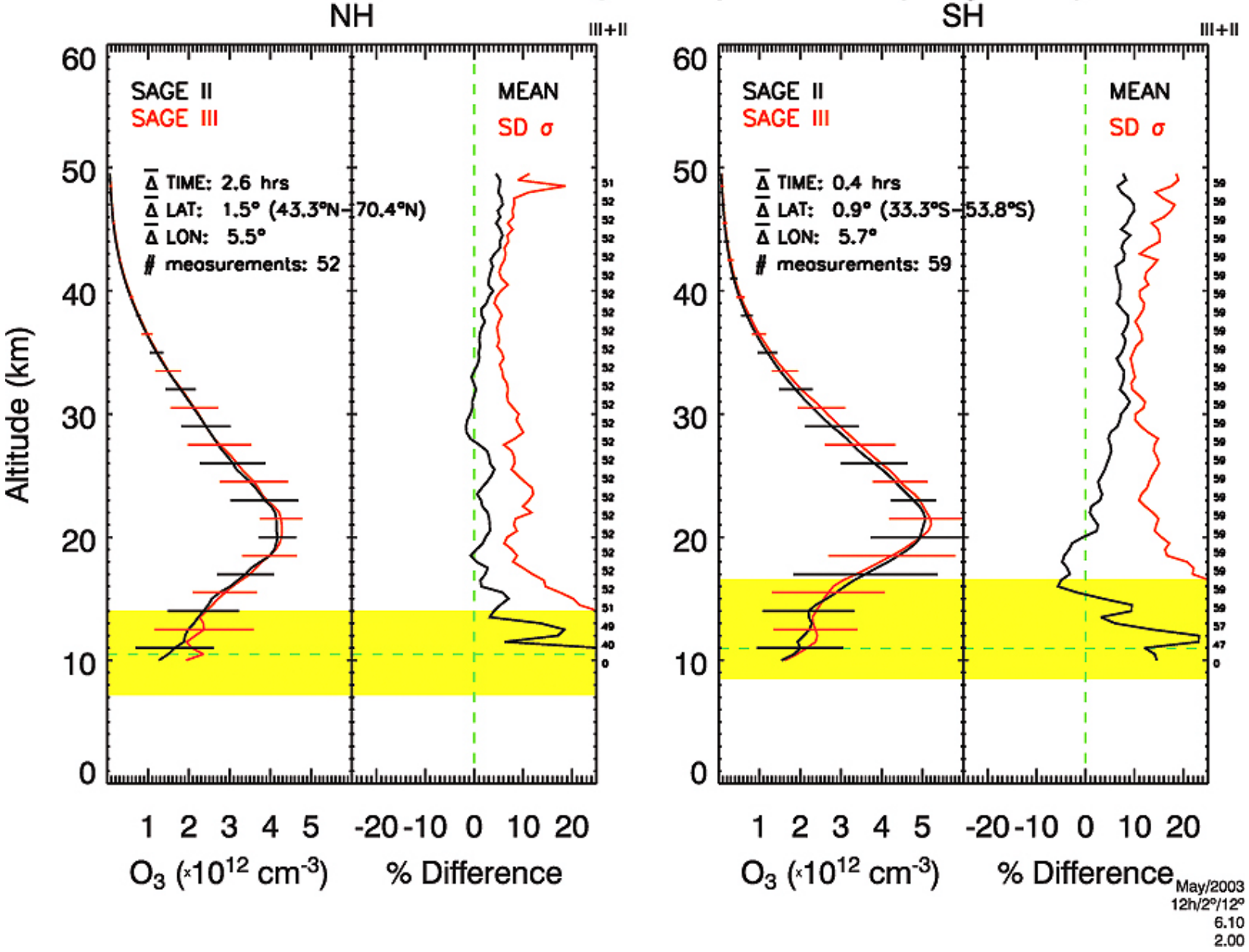


an Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar

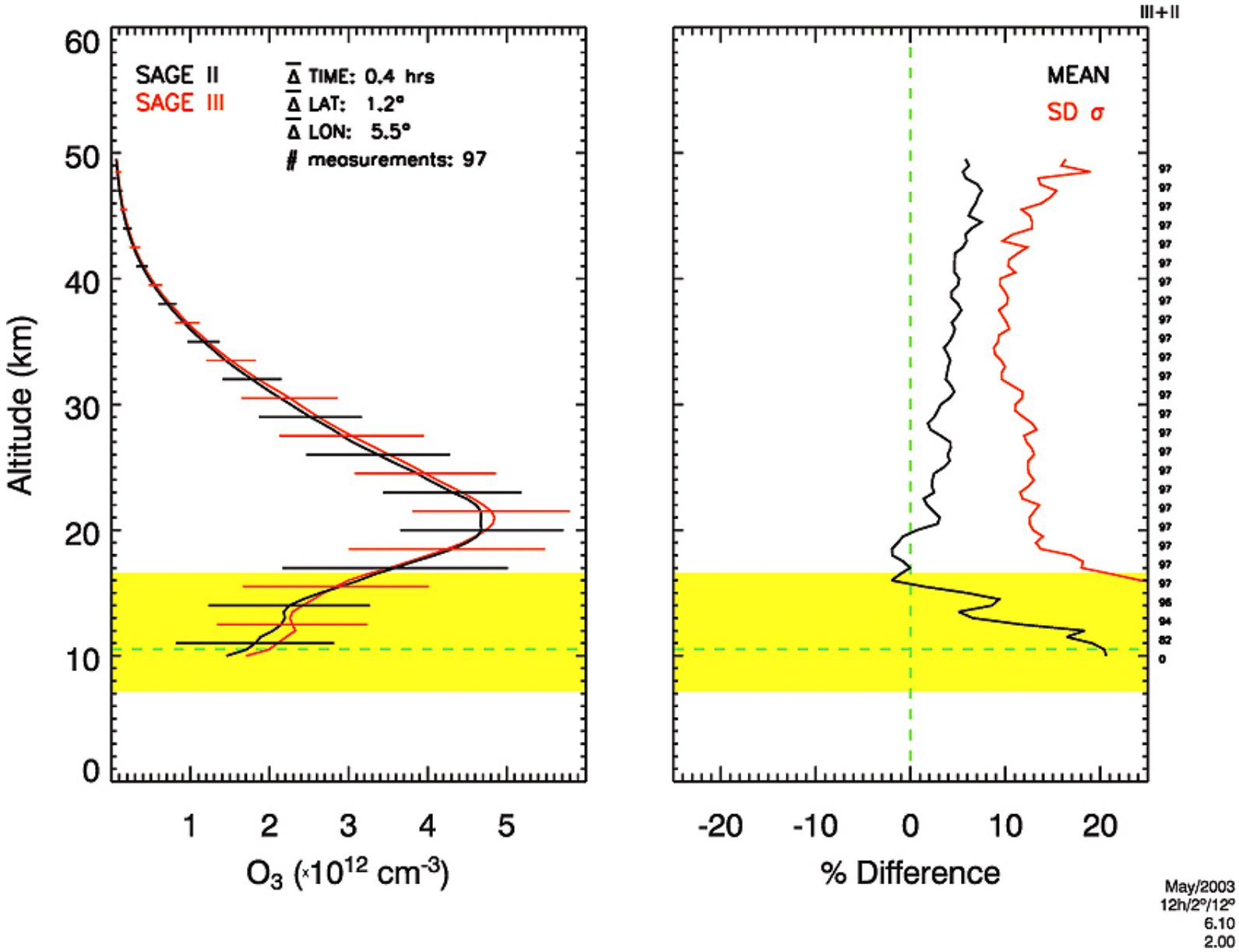
Month

SAGE II Sunrise
SAGE II Sunset
SAGE III Sunrise
SAGE III Sunset

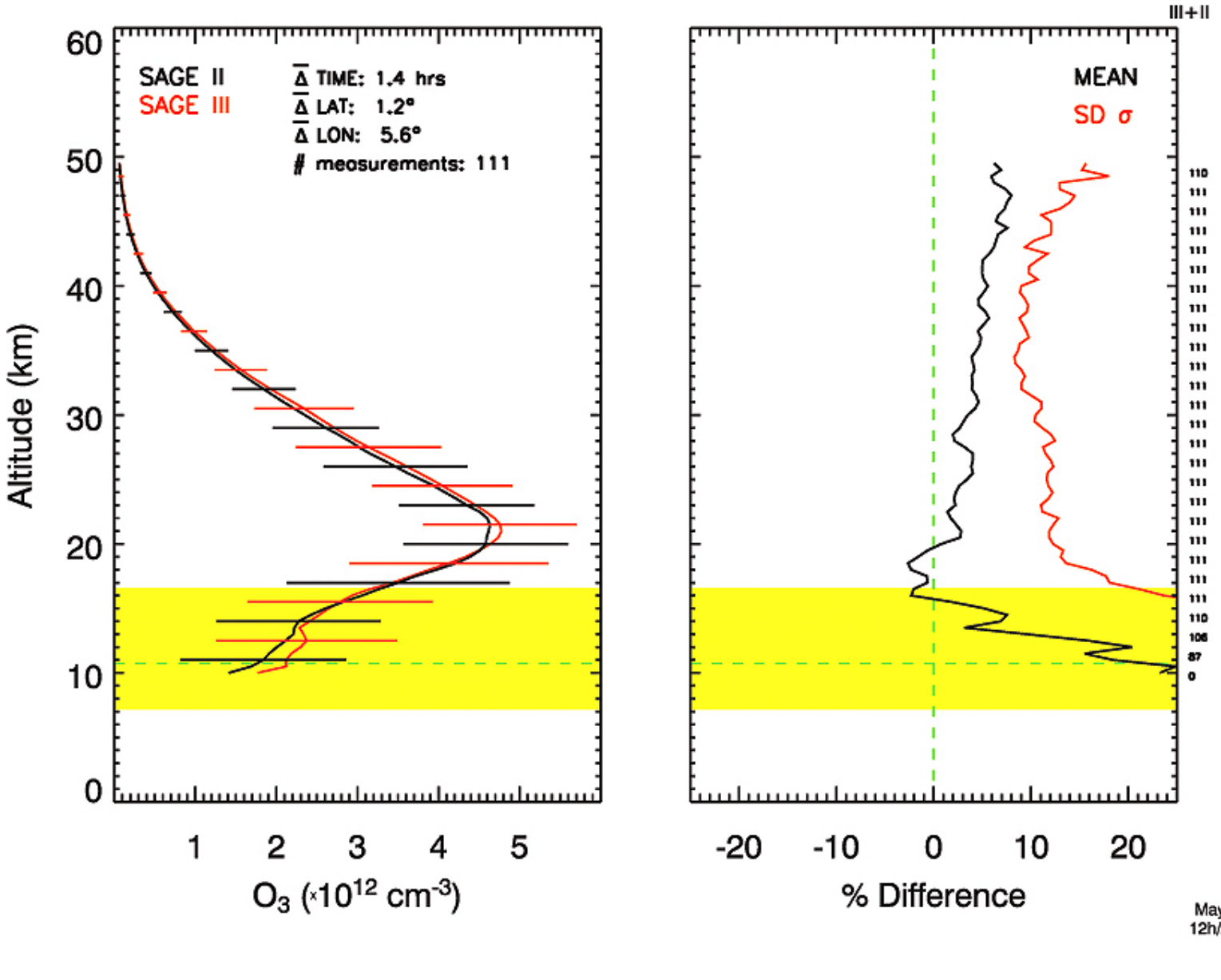
Apr/2003
6.10
2.00


SAGE II/SAGE III O_3 Comparisons (May-Feb)
NH
SH
III+II
SAGE II
SAGE III
MEAN
SD σ
Δ TIME: 2.6 hrs
Δ LAT: 1.5° (43.3°N–70.4°N)
Δ LON: 5.5°
measurements: 52
Δ TIME: 0.4 hrs
Δ LAT: 0.9° (33.3°S–53.8°S)
Δ LON: 5.7°
measurements: 59
Altitude (km)
O_3 (×10^{12} cm^{-3})
% Difference
May/2003
12h/2°/12°
6.10
2.00

SAGE II/SAGE III SS O_3 Comparisons (May-Feb)



Composite of SAGE II/SAGE III O_3 Comparisons (May-Feb)



SAGE II Ozone Model

Applied multiple linear regression including mean, linear, annual, semi-annual QBO, Solar, and autoregressive noise terms.

$$O_3(t) = b_o + b_1 t + b_2 \cos(2\pi t) + b_3 \sin(2\pi t) + b_4 \cos(4\pi t) + b_5 \sin(4\pi t)$$

$$+ \text{QBO} + \text{Solar} + \text{Noise}$$

*Use Normalized F10.7 flux for solar proxy

*QBO is determined from a linear combination of the Singapore Zonal Winds

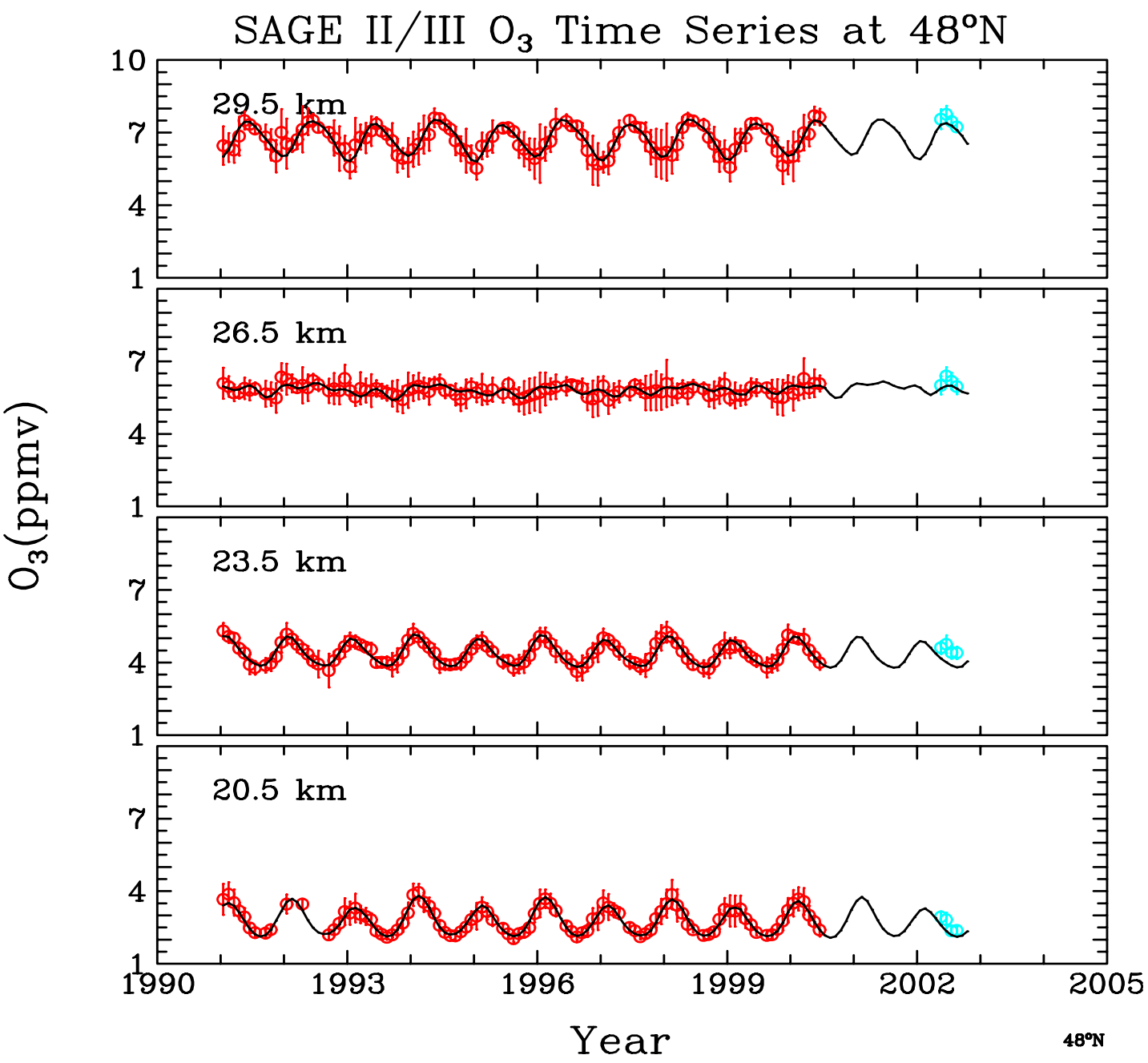
Applied Principal Component Analysis (PCA) to Singapore winds at 7 vertical pressure levels

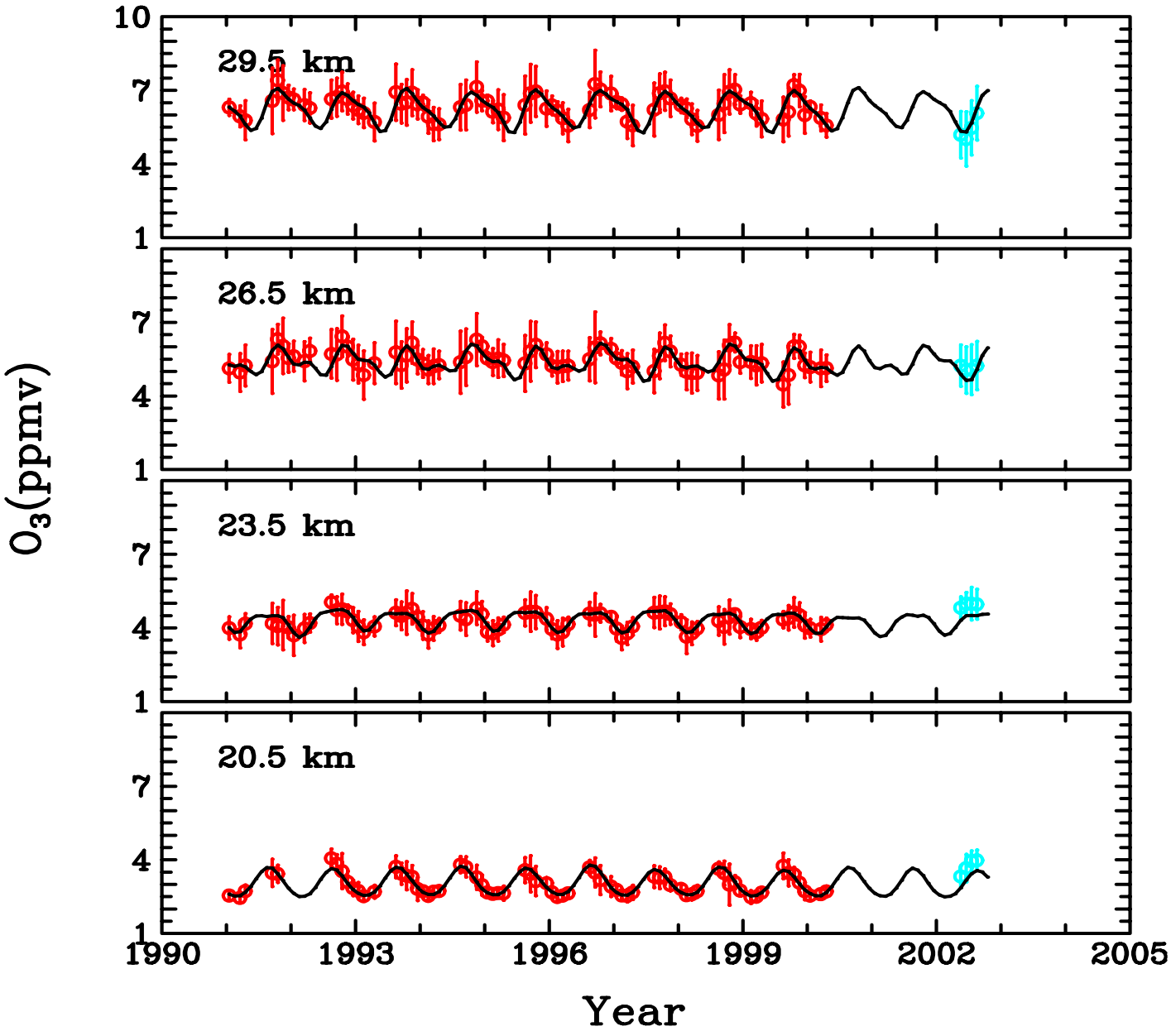
- Retained first 2 principal components (pc_1 and pc_2) associated with the first 2 empirical orthogonal functions (eof's). The first 2 eof's capture ~93% of the total variance of the original Singapore wind field [Wallace et al., 1993]

- To add seasonality, multiply each of the pc's by mean and annual oscillation terms [Randel and Wu, 1996]

$$qbo_1 = pc_1(c_0 + c_1\cos(2\pi t) + c_2\sin(2\pi t))$$
$$qbo_2 = pc_2(d_0 + d_1\cos(2\pi t) + d_2\sin(2\pi t))$$

$$QBO = qbo_1 + qbo_2$$


SAGE II/III O_3 Time Series at 48°N
29.5 km
26.5 km
23.5 km
20.5 km
O_3(ppmv)
10
7
4
1
1990
1993
1996
1999
2002
2005
Year
48°N


SAGE II/III O_3 Time Series at 56°S
29.5 km
26.5 km
23.5 km
20.5 km
O_3(ppmv)
10
7
4
1
1990
1993
1996
1999
2002
2005
Year

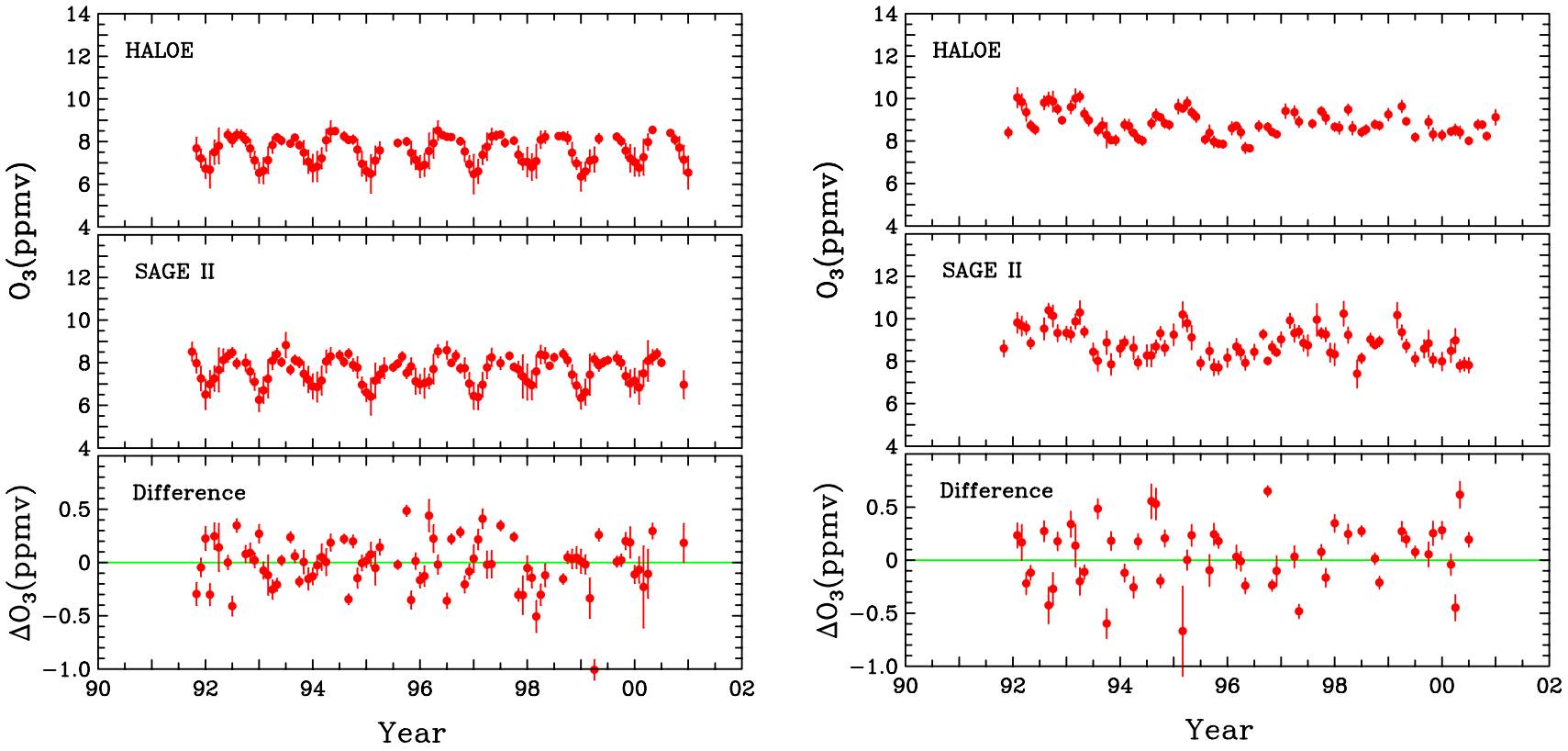
SAGE II and HALOE Trends Analysis

- Let SAGE II = $y(t)$ and HALOE = $x(t)$ in a fixed latitude band and altitude over the UARS time period.

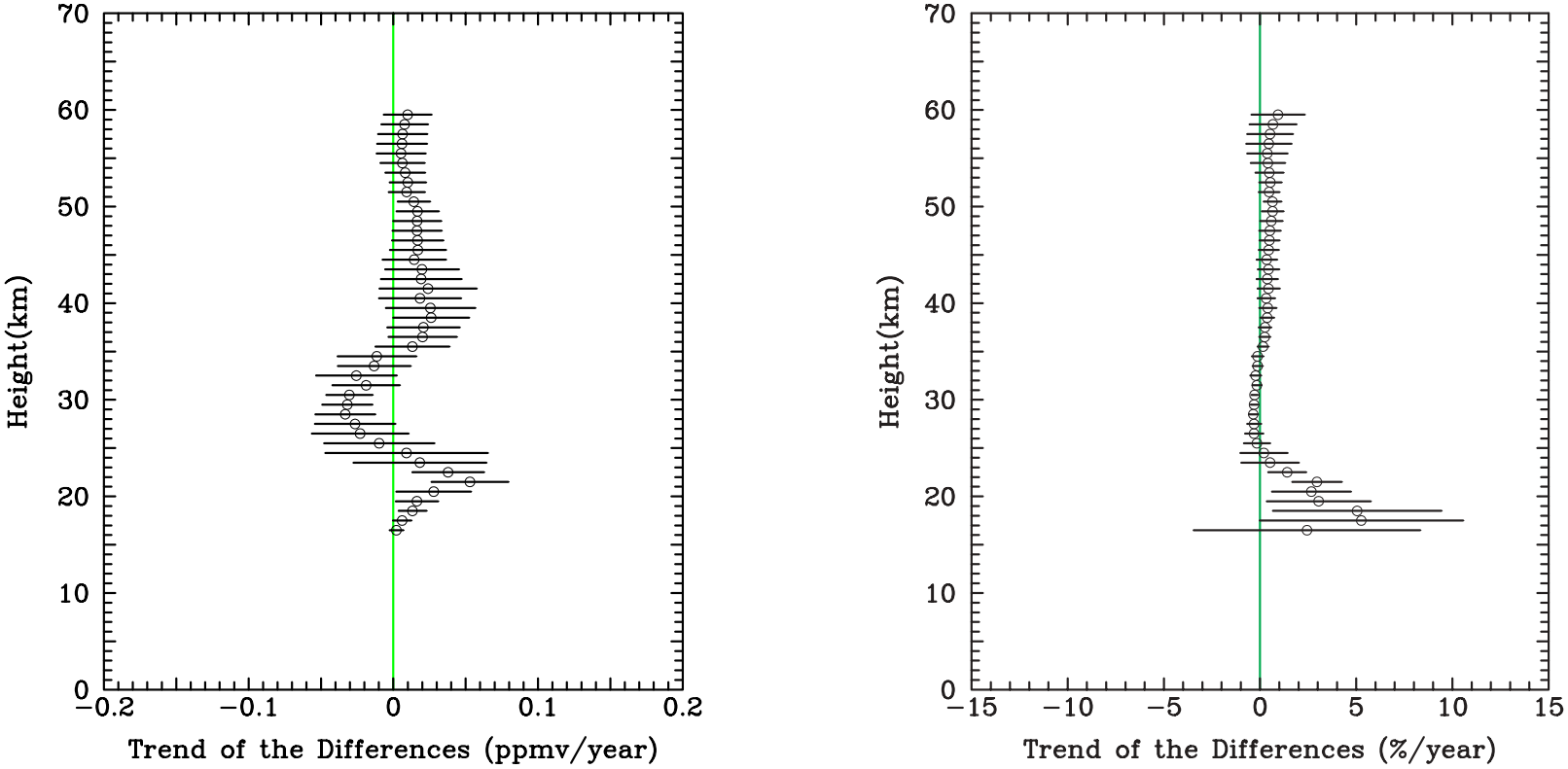
- The monthly difference time series for pair-wise points is defined by $\Delta(t)=x(t)-y(t)$.

- Fit the difference time series to the following linear model:

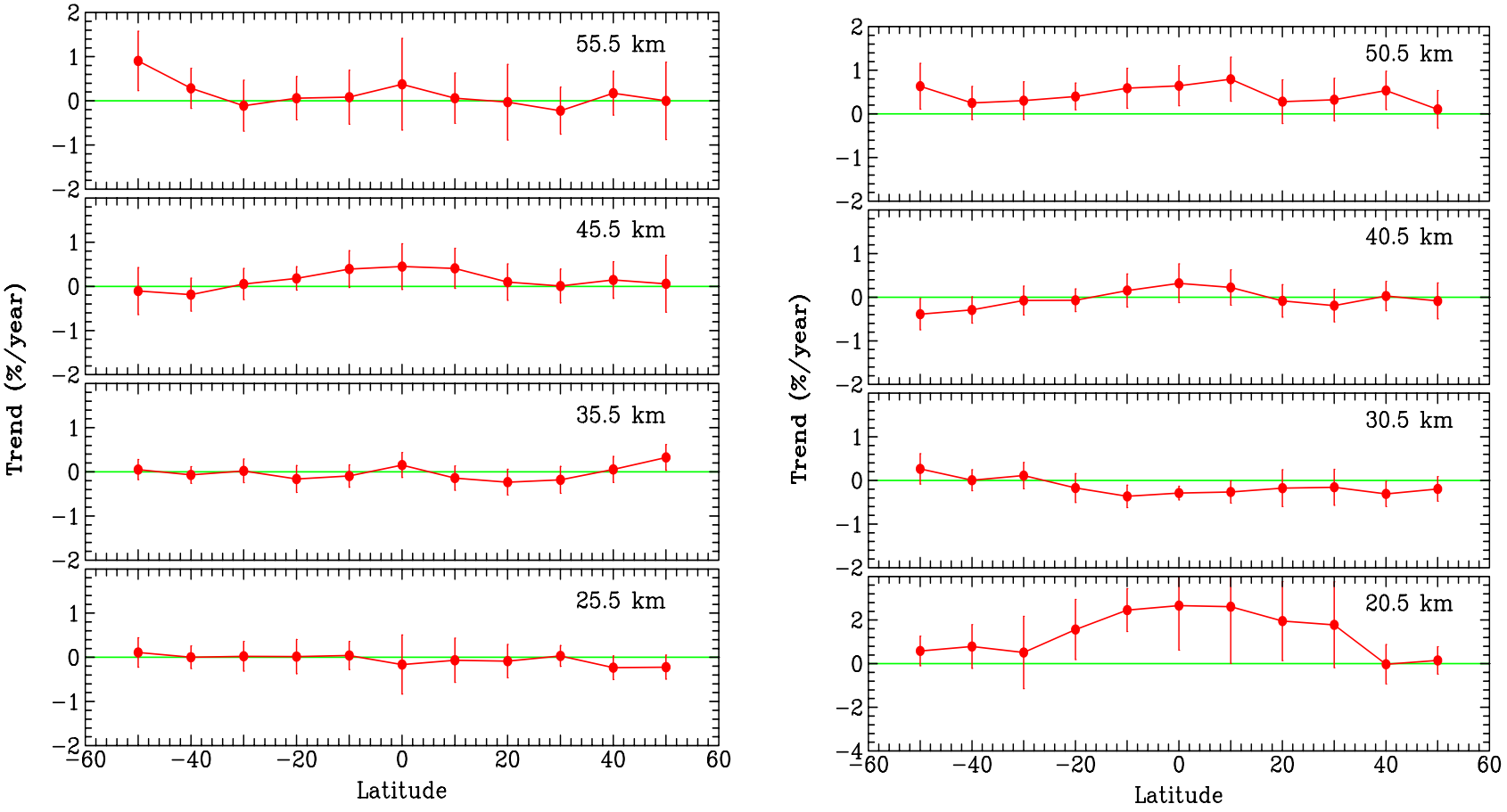
$$\Delta(t)= b_0 + b_1 t + noise$$



Monthly ozone time series of HALOE v19 (top frames), SAGE II v6.1 (middle frames), and the HALOE-SAGE II differences (bottom frames). The time series are located at 35.5 km and centered at 40^{o}+/-5^{o} N (left frame) and 0^{o}+/-5^{o} latitude (right frame).



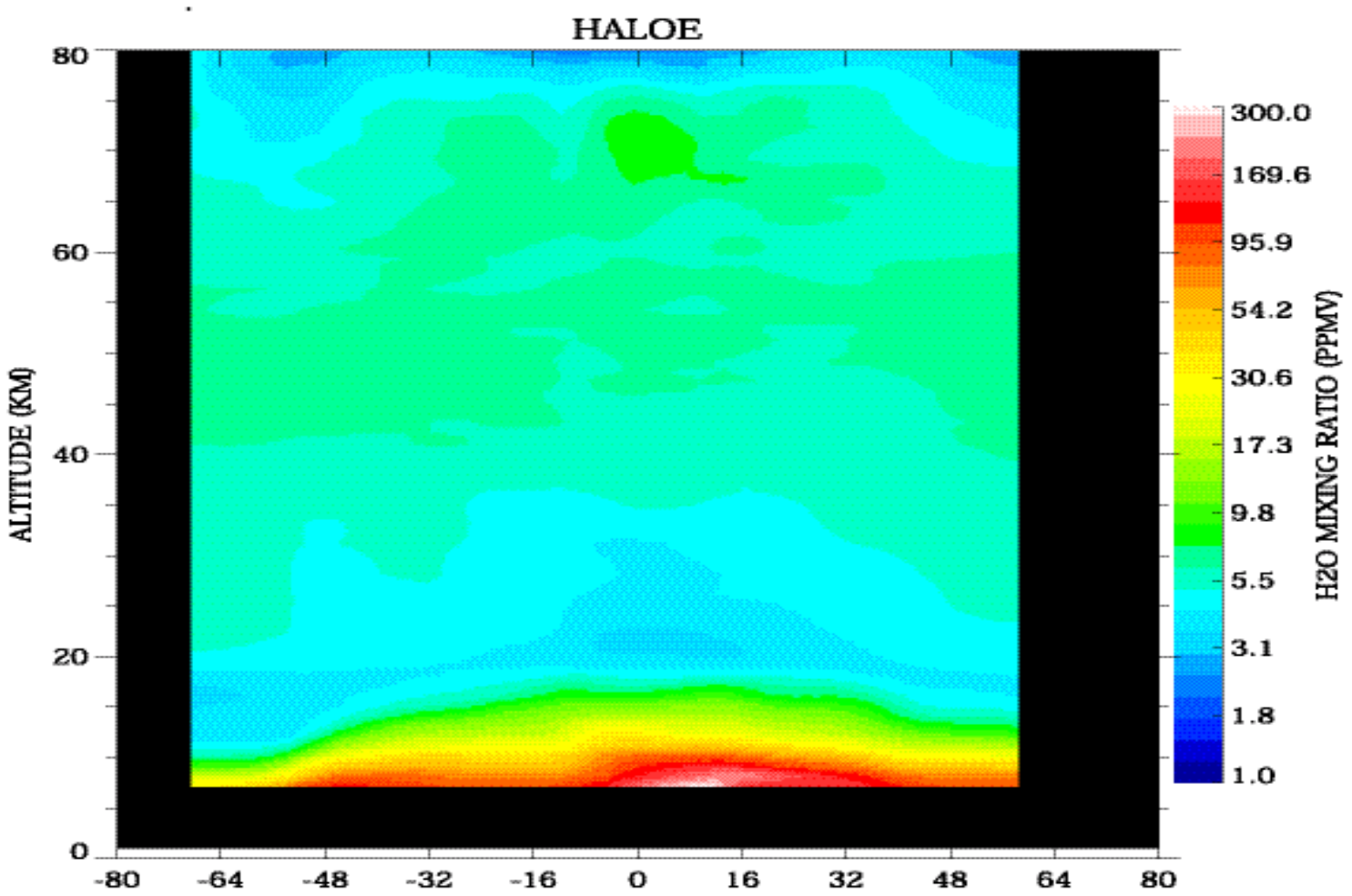
Vertical distribution of the trends of the ozone percent differences (%/year, left frame) and absolute differences (ppmv/year, right frame) between HALOE v19 and SAGE II v6.1 retrievals at the equator (+/-5^{o} latitude). The error bars represent the 95% confidence interval.



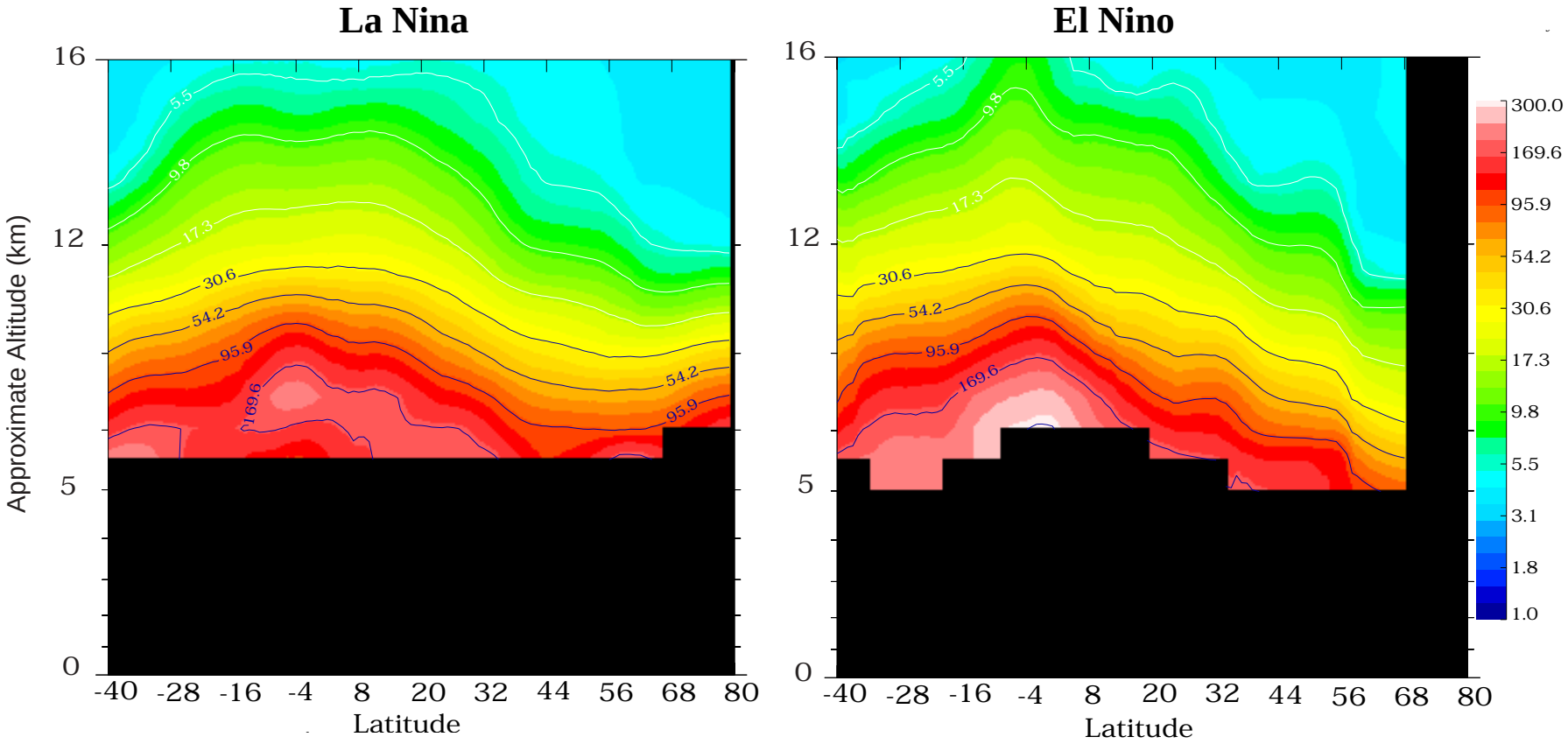
Zonal trends (%/year) of the ozone difference time series between HALOE v19 and SAGE II v6.1 retrievals at various altitudes. The error bars represent the 95% confidence interval. Note the change in scale of the trends at 20.5 km.

Validation of the HALOE 4'th Public Release

- Will focus on lower stratosphere/upper troposphere H_2O and O_3 (below 30 km)
- For H_2O, will rely on archived data from major air campaigns, ground-based measurements, POAM III, and MOZAIC
- For O_3, will rely mainly on solar occultation instruments and ground-based sondes



H_2O v20 latitude cross section retrieval for September 18 to November 26, 1995 showing the entire altitude range from ~7 km to 80 km. Note that the retrieval extends ~9 km below the tropical tropopause.



HALOE Tropospheric H_2O for La Nina (fall/winter 95'- 96') and El Nino (fall/winter 97'-98') periods showing water vapor enhancement due to El Nino event.

Summary of Present and Future Work

- Validation
  - SAGE II v6.2, SAGE III v?.?, HALOE v20 (H_2O and O_3), and subsequent datasets
  - Comparisons with other instruments
  - Compare profiles by potential vorticity

- Climatology/Trends
  - SAGE III Bridgework
  - SAGE II and HALOE Difference time series
  - Upper troposphere O_3 and H_2O